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SINTERING OF FIRECLAY-KAOLIN MIXTURES WITH REFRACTORY CLAY

L. D. Pilipchatin[1]

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It is shown that the sintering of fireclay-kaolin mixtures is intensified by the replacement of refractory easily sintering plastic clays by high-melting clay. Recommendations are given on the choice of the method for preparation and introduction of the mentioned additive into the mixture. The developed technology has been tested under industrial conditions.

In order to improve compaction and hardening of fireclay-kaolin mixtures in pressing and roasting, refractory plants commonly use easily sinterable plastic clays as a plasticizing and sintering additive. In their absence fireclay parts are produced on a kaolin binder, which requires elevated roasting temperatures [1] and does not guarantee a high quality of the products.

Many additives recommended for compaction and hardening of fireclay refractories from kaolin raw materials have been used by refractory enterprises. These are triethanolamine, bentonite, sodium tripolyphosphate, etc. [1 – 3]. However, their use is limited by different reasons.

In the present paper we will discuss the results of laboratory tests and industrial experiments on the use of a particolored refractory clay for compaction and hardening of fireclay refractories produced from kaolin raw materials of the Vladimirovskoe deposit.

The particolored clay is represented by overburden rocks that get into dumps of kaolin mines. The content of alkaline and alkaline-earth oxides in the clay amounts to 8 – 10% (here and below in mass fractions). The elevated content of these oxides allows us to predict that the clay can be a promising sintering additive for kaolins.

An earlier performed study has shown that when Vladimirovskoe kaolin is sintered at a temperature exceeding 1500°C, it should be enriched with 15% particolored clay in order to prevent bloating.

We have studied different techniques for the introduction of particolored clay into the fireclay-kaolin mixture and determined its optimum content for the additive to be most effective. The particolored clay was added into the mixture in the form of a powder (binder) in a coarse disperse state (a fraction finer than 0.54 mm), with slip, and with a jointly milled mixture (JMM) with a part of the fireclay. Before introducing the clay with powder or slip into the mixture, the clay was thickened by passing it through a screen with cells 0.4 mm in diameter and then subjected to dehydration. When introduced with the JMM, the clay was not thickened.

The particolored clay was introduced instead of kaolin into a charge of the following composition: 65% ShKV-1 fireclay of a fraction 3 – 0 mm in size, 15% finely milled ShKV-1 fireclay, and 20% kaolin of grade KV-1.

We studied specimens 36 and 38 – 40 mm in diameter. The specimens were pressed in a hydraulic press under a pressure of 50 MPa. The moisture content of the mixture was 6.0 – 6.5%. The specimens were roasted in a tunnel kiln.

The main properties of green and roasted specimens with added powder (binder) and slip are presented in Figs. 1 and 2. For comparison, we present in the same figures the properties of specimens from commercial charges (0′ and 0″) the compositions of which involved a mixture of DN-2 and KV-1 kaolin in a 1-to-1 and 1-to-2 proportion, respectively. The specimens were roasted at 1500°C.

It follows from the presented data that the particolored clay introduced into the mixture instead of kaolin improves the compactibility of the mixture. For example, the apparent density of the green charge without clay is 2.135 g/cm^3, whereas with the introduction of 4% clay this parameter increases to 2.15 g/cm^3. When 4% clay is introduced with slip, the apparent density of the greenware amounts to 2.175 g/cm^3. In this case the particolored clay acts as a stronger plasticizer than when it is introduced with a powder binder.

Particolored clay also provides a more intense sintering of the fireclay-kaolin mixture. Without this clay the open porosity of the roasted specimens is equal to 18.7%. Upon the introduction of 4% clay in powder form the open porosity of the specimens decreases to 17.5%. When the same amount of clay is introduced with slip, the open porosity of the roasted

[1] State Metallurgical Academy of Ukraine, Dnepropetrovsk, Ukraine.

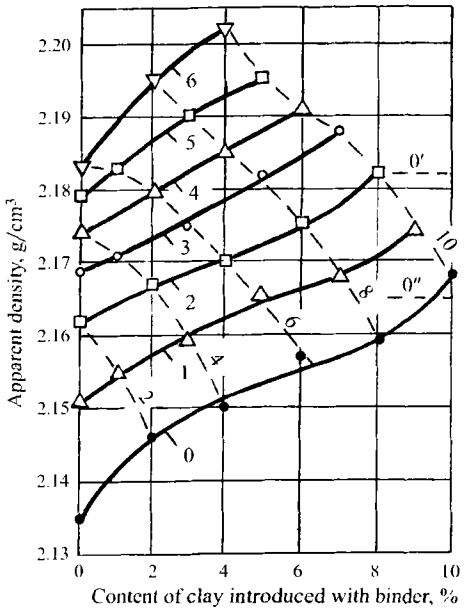

Fig. 1. Dependence of the apparent density of green specimens on the content of particolored clay introduced into the mixture with binder and slip: the numbers at the curves denote the percentage of clay introduced with slip (solid lines) and the total clay content (%) (dashed curves).

specimens decreases to 16.0%. The strength of the specimens with clay introduced with slip is higher than when it is introduced with the binder. Thus, the slip method of introduction of particolored clay provides greater compaction and hardening of the fireclay-kaolin mixture than the powder (binder) method.

The content of particolored clay sufficient for fabrication of specimens with a porosity and hardness no less than those of specimens from commercial mixtures (0′ and 0″) in the case of the powder method of introduction exceeds 10%. In the case of the slip method it is sufficient to add 4 – 6% particolored clay.

In should be noted that the introduction of a large amount of particolored clay (4 – 6%) with slip can be impossible because of the limited possibilities of the method. The introduction of particolored clay with the binder can worsen the appearance and properties of the parts because of the dark-brown points and spots on their surface. The latter are formed as a result of melting of comparatively coarse clay particles. The mentioned defects are caused by rough milling and the high necessary content of particolored clay.

We have also studied the possibility of the use of particolored clay introduced into the mixture by the method of joint milling and determined its optimum content. In parallel, the clay was introduced into the charge with slip and by a combined method. The clay content in the charges was 0, 2, 4, 6, and 8%.

We established that the most effective way to prepare particolored clay consists in its thickening and fine joint

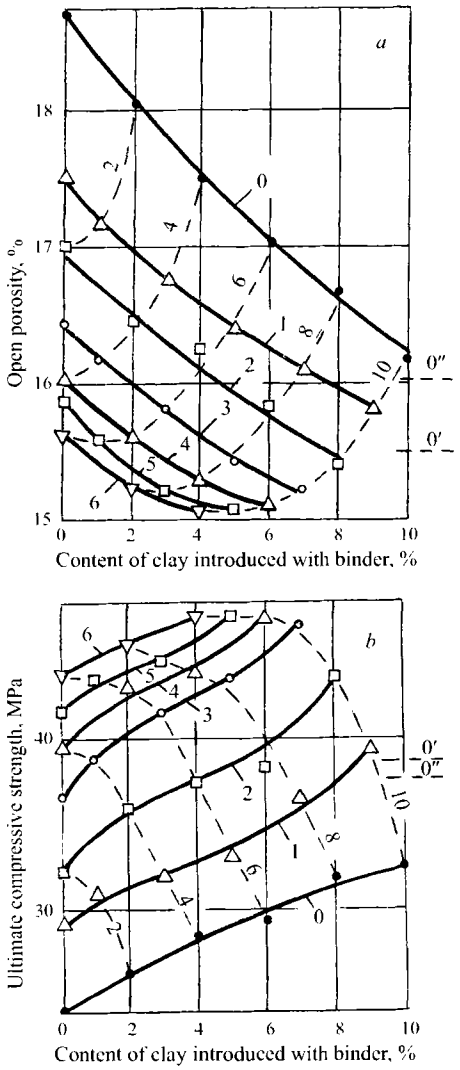

Fig. 2. Dependence of the open porosity (*a*) and the ultimate compressive strength (*b*) of specimens on the content of particolored clay introduced into the mixture with binder and with slip: the notation is as in Fig. 1.

milling with a part of the fireclay. A possible variant is the use of unthickened particolored clay, but this gives somewhat worse results. However, it is simpler to realized. Therefore, we used JMM with unthickened clay. The specimens were roasted at 1460°C.

The obtained data have confirmed the positive effect of a partial replacement of kaolin by particolored clay on the compactibility of the mixture. It has been shown that the specimens are pressed more easily when the additive is introduced by the method of JMM than with slip. For example, when 4% clay is introduced with slip, the apparent density of the green specimens is 2.16 g/cm^3. When the same amount of clay is introduced with JMM, the green specimens are compacted to an apparent density of 2.18 g/cm^3.

Analyzing the obtained results, we determined the influence of the methods of introduction of the additive on the

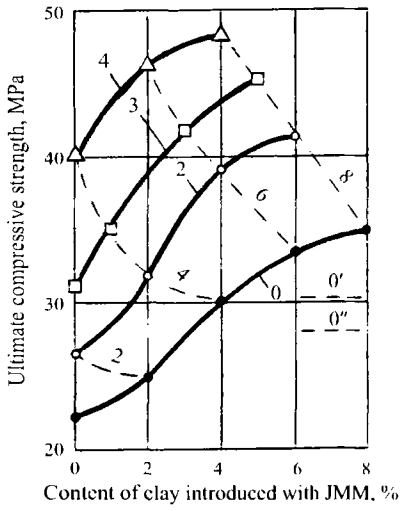

Fig. 3. Dependence of the ultimate compressive strength of specimens on the content of particolored clay introduced into the mixture with JMM and slip: the notation is an in Fig. 1.

properties of the roasted specimens. We established that the efficiency of the use of particolored clay for compaction of the specimens is higher when it is introduced into the mixture with JMM than with slip. The difference in the open porosity of the roasted specimens as a function of the method of introduction of the additive amounts to 1.0 – 1.5%. This means that if the open porosity should be diminished as the most important parameter, for example, for ladle bricks, the particolored clay should be introduced with JMM.

The effect of the methods of introduction of particolored clay on the strength of roasted specimens turned out to be quite opposite. At an equal content of the clay the strength of the specimens was higher when it had been added into the mixture with slip and not with JMM (Fig. 3). Therefore, if it is required to increase the strength of the specimens, the particolored clay should be introduced into the mixture with slip.

Thus, the method of introduction of particolored clay should be chosen depending of what properties of the roasted specimens have to be improved. The open porosity increases to a greater extent when the clay is introduced into the mixture with JMM. In order to increase the strength of the material, the clay should be added with slip. We used this conclusion to develop temporary technological instructions for the production of general-purpose fireclay refractories with an additive of particolored clay for the Velikoanadolskii refractory plant.

In order to provide an open porosity and a strength similar to those of critical parts produced from commercial mixtures 0′ and 0″, the fireclay-kaolin mixture should be enriched with 3 – 4% particolored clay by the method of JMM. This is a much lower content than when the clay is milled into coarse particles. After recalculation for finely milled fireclay and kaolin, the content of particolored clay in them turns out to be 8.6 – 11.2%, which is much lower than the maximum permissible content (15%) of the additive for roasting at a temperature below 1500°C.

It should also be noted that when the mixture is enriched with particolored clay in a finely milled state or with slip, the roasted specimens have a uniform light creamy color.

We used the results of laboratory tests to develop temporary technological instructions for the production of heavy-duty and general-purpose parts. Pilot batches of such parts have been manufactured at the Velikoanadol'skii refractory plant. It turned out that the DN-2 clay used in the production of fireclay refractories based on raw components from the Vladimirovskoe deposit can be replaced by the particolored clay.

Pilot ladle bricks have been tested in service. The results of the tests have been positive.

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